EP 225.3
Department of Physics and Engineering Physics
University of Saskatchewan
Final Examination

Instructor: A.V. Koustov
Time: 2:00 pm – 5:00 pm

April 13, 2006

Notes: **Candidates are to answer all 10 questions**
All questions have the same value
No book or notes, formula sheet is provided
Any hand-held calculator is allowed

1. (a) A diver (without a mask) watches a small fish (assume $n_1 = 1.3$ for water). Suddenly, a gas bubble ($n_2 = 1$) of radius R appears between the eye and the fish. Distance between the fish and the center of the bubble is $3R$; the eye is located $4R$ away from the bubble's center as shown in Fig. 1. How large is the fish for the diver now? Where is it located? Is it inverted or upright? Solve the problem by applying the surface (Gauss) equation.

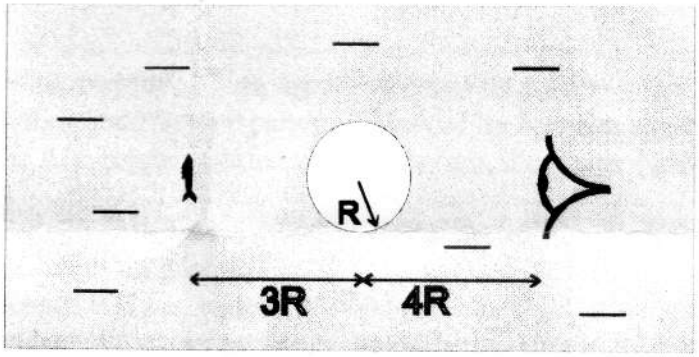

Figure 1:

2. An object is placed 5 *cm* from the front surface of a thin biconcave (negative) lens with the radius of the surfaces of 10 *cm*. The lens is made of glass with n=1.5. (a) Using the thin lens equation in Newton's form calculate the image location with respect to the object. (b) Find the image location with respect to the object by using the matrix method.

3. (a) A certain microscope has an objective and eyepiece of focal lengths 16 *mm* and 5 *cm*, respectively. The distance between the objective and eyepiece lenses is 22 *cm*. The final image formed by the eyepiece is at infinity. (a) What should be the distance from the objective to the object viewed? (b) What is the linear magnification produced by the objective lens?
(c) What is the overall magnification of the microscope?

4. (a) A 10.6 *kg* object oscillates at the end of a vertical spring that has a spring constant of 2.05×10^4 *N/m*. The effect of air resistance is represented by the damping coefficient 3.00 *Ns/m*. (a) Calculate the frequency of the damped oscillation (b) By what percentage does the amplitude of oscillation decrease in each cycle? (c) Find the time interval that elapses while the energy of the system drops to 5% of its initial value.

(b) Show that in a resonant LCR series circuit the maximum potential across the condenser occurs at a frequency $\omega = \omega_0(1-1/2Q_0^2)^{1/2}$ where $\omega_0^2 = (LC)^{-1}$ and $Q_0 = \omega_0 L/R$.

$\omega = \frac{1}{\sqrt{LC}}\sqrt{1-\frac{R^2}{2\omega_0^2L^2}}$ $\quad \frac{\omega_0^2L^2}{R^2}$ $\quad \frac{R^2}{2\omega_0^2L^2}$

5. (a) A wave group consists of two wavelengths λ and $\lambda+\Delta\lambda$ where $\Delta\lambda/\lambda$ is very small. Show that the number of wavelengths λ contained between two successive zeros of the modulating envelope is $\approx \lambda/\Delta\lambda$. Remember that $\sin\alpha+\sin\beta=2\sin\frac{\alpha+\beta}{2}\cos\frac{\alpha-\beta}{2}$.

6. The intensity of sound waves near a jet engine is about 0.1 W/m^2. Assume T= 20^{0}C, 1 atm pressure ($P=10^5 N/m^2$), $\rho_v = 1.2\ kg/m^3$ and $\nu = 2$ KHz. The ratio of specific heats=1.4.

(i) What is the amplitude of displacement wave ξ_0?

(ii) What is the amplitude of pressure wave?

(iii) What would be the intensity of the sound in water near the surface and would the sound be detected by a human under the water? Water has bulk modulus of $2.1\times10^9 N/m^2$ and density of $1\ g/cm^3$.

7. Monochromatic light in visible part of the spectrum is incident normal on a thin film of oil (n=1.30) that covers a glass plate. The thickness of the oil film is 400 nm. Determine two wavelengths for which one would see a complete destructive interference in reflected light (assume that $n_{oil} < n_{glass}$).

8. Two parallel slits, each with a width of $1\mu m$, are illuminated by a plane wave of light with a wavelength of 500 *nm*. The resulting interference pattern is viewed on a screen at a large distance from the slits. It is found that the fifth bright-interference fringe from the center (counting the center one as ``zero") is missing.

(a) At what angle from the center line does this first diffraction minimum lie?

(b) What is the separation between the two slits?

(c) If light with a wavelength 600 *nm*, instead of 500 *nm*, were used, at what angle would the first diffraction minimum lie? Which bright fringe would be missing in this new pattern?

9. Sodium vapor light has a nominal wavelength of 589.3 *nm*, but the light actually consists of two components of nearly equal intensity separated by small $\delta\lambda$. When a sodium vapor source is used in a Michelson interferometer, one observes that as one of the mirrors is moved, the fringes become soft and fuzzy, then sharp and clear and so forth. (a) Explain why this happens. The distance that the mirror must be moved between successive appearances of sharp fringes is 0.3 *mm*. (b) What is the wavelength separation $\delta\lambda$ of the two components of the light? Explain your solution.

10. (a) Two polarizers are positioned with their transmission axes at right angles. A third polarizer is placed in between the original crossed polarizers.

(i) Derive an expression for the intensity of light transmitted through the three-piece combination as a function of the angle θ between the transmission axes of the first polarizer and the middle one. The incident light is unpolarized and has intensity I_0.

(ii) At what angle θ the passing light is at maximum?

(b) On a sunny day, light coming out of Lake Louise in Rocky Mountains is blue while light coming from a creek flowing into the lake from the glacier up in the mountains is nearly white. Explain the difference in colors by considering mechanisms of light scattering.